

NASA/Tropical Rainfall Measuring Mission (TRMM)

Topic #2: Hurricanes As Heat Engines

Teacher's Guide

Grades: 6-9

Overview: This topic is designed to increase students' understanding of the "ingredients" necessary for the formation of hurricanes and provide NASA satellite images of storms for student interpretation. One of the key points is that latent heat which is stored in the water vapor that evaporates from warm oceans, provides the energy that is converted into wind and rain. This process of converting the heat from oceans to the energy of a storm is the reason some scientists refer to hurricanes as "heat engines". The TRMM satellite measures rainfall which is produced when latent heat is released during condensation. Therefore, TRMM instruments are valuable for monitoring the development of hurricanes.

National Science Education Content Standards: The activities provided in this lesson meet Content Standards A,B,D,E,F and G. A comprehensive list of the Content Standards and relevant subtopics is located on page 5 of the Teacher's Guide.

Activity #1:

How do hurricanes convert heat into a powerful storm?

- **Objective:** To identify the role of latent heat as the energy source for the strength of a hurricane.
- **Type of Activity:** Students construct a diagram of a hurricane. Pieces of the diagram are conditions needed for the formation of a hurricane. Flip-up pieces provide deeper understanding. Pieces that unfold reinforce the role of latent heat as the "heat engine".
- **Background** – Provides students with basic understanding of "ingredients" necessary for the formation of a hurricane. Key points are bold faced.
- **Materials-** List items needed per student or per group to complete the activity. Note that each diagram will require 3 pages: "Diagram", "Hurricane Conditions for Diagram" page 1 and 2.
- **Procedure-** List directions for constructing the diagram. Note that page 4 of the Teacher's Guide shows a completed diagram.
- **Analysis** – Students are to use the "Background" section and the completed "Diagram" to respond the questions.

ANSWERS to “Analysis” questions

1. Warm humid air rises, cools, condenses and releases latent heat. This latent heat warms the surrounding air which makes the air more likely to rise.
2. Air moves into the storm to replace the rising air. Water vapor in the air condenses into clouds, which ultimately produce rain.
3. Hurricanes require a source of warm humid air for a source of energy. Cool water or land surfaces do not supply these needs.
4. Increases in the global temperature could warm the oceans. Warmer oceans may lead to more frequent and more intense hurricanes.
5. Hurricanes begin in the tropical regions because they draw their power from the humid air over tropical oceans.
6. Scientists discovered that Hurricane Bonnie intensified after developing towering clouds around the eye wall. These new observations may help scientists predict the severity of storms.

Activity #2: Satellite Images of Hurricane Rainfall Data

- **Objective:** To interpret satellite images of hurricane rainfall data.
- **Type of Activity:** Students analyze NASA/TRMM satellite images of hurricanes.
- **Background** –Narrative explains the role of latent heat as a source of energy for hurricanes and describes the role of TRMM’s instruments in monitoring these storms.
- **Vocabulary-** Definitions are listed for bold-faced words in the “Background”.
- **Materials-** The activity may be completed using (1) Internet access for each student, (2) color copies of the images from the URL addresses listed below or (3) color transparencies. The images located at these URL sites are also included at the end of the activity and are listed as part of the “Visuals” section of the Main Menu under “Educational Resources”. A copy of the INTERNET ACTIVITY SHEET “Hurricanes As Heat Engines” should be provided for each student.

URL addresses:

<http://trmm.gsfc.nasa.gov>

<http://trmm.gsfc.nasa.gov/data/HurrMitch981027.1.MD.JPEG>

http://trmm.gsfc.nasa.gov/data/trmm3dcyclonesusan_md_new.html

<http://trmm.gsfc.nasa.gov/data/bigbonnie1.md.jpg>

<http://trmm.gsfc.nasa.gov/data/9711hurrslicethrubg.html>

http://trmm.gsfc.nasa.gov/data/pam_closeup_md.html

- **Procedure-** Adjust your procedure for the materials available at your site. Students are to use the satellite images to respond to questions A to P on the

INTERNET ACTIVITY SHEET” Hurricanes As Heat Engines”

ANSWERS:

- A. No
- B. No
- C. The eye is light blue which indicates that it has less rain than the red region surrounding it.
- D. Dark blue, green, yellow, pink, yellow, green, dark blue, light blue
- E. Latitude: 14 South and Longitude 170 East
- F. 5th, January 1998
- G. The tall clouds may indicate that the air pressure is dropping. Winds may increase resulting in an increase in the storm's intensity.
- H. The tallest cloud is likely producing the greatest amount of rain.
- I. The towering clouds are releasing a significant amount of latent heat as they produce heavy amounts of rain. The introduction of this released latent heat may aid in the development of these tall clouds causing them to “tower” over the surrounding storm clouds.

Sketch of the tall clouds in Hurricane Bonnie

- J. The tops of the clouds are irregular with sharp spikes of clouds
- K. Light blue
- L. Bottom
- M. The yellow and red areas form tall narrow columns, sometimes developing a horizontal layer at the top of the column
- N. 9 km
- O. 200 km
- P. 20 South Latitude, 160 West Longitude

• **Other Related Web Sites**

USA Today “Why hurricanes form over warm oceans”

<http://www.usatoday.com/weather/whur7.htm>

USA Today “Latent heat provides fuel for storms”

<http://www.usatoday.com/weather/wlatent.htm>

Hurricane Stages of Development

<http://cavis.atmos.uiuc.edu/guide/hurricane/html/stages.html>

Tracking Hurricanes Using Satellite Imagery

<http://www.comet.ucar.edu/nsflab/web/hurricane/331.htm>

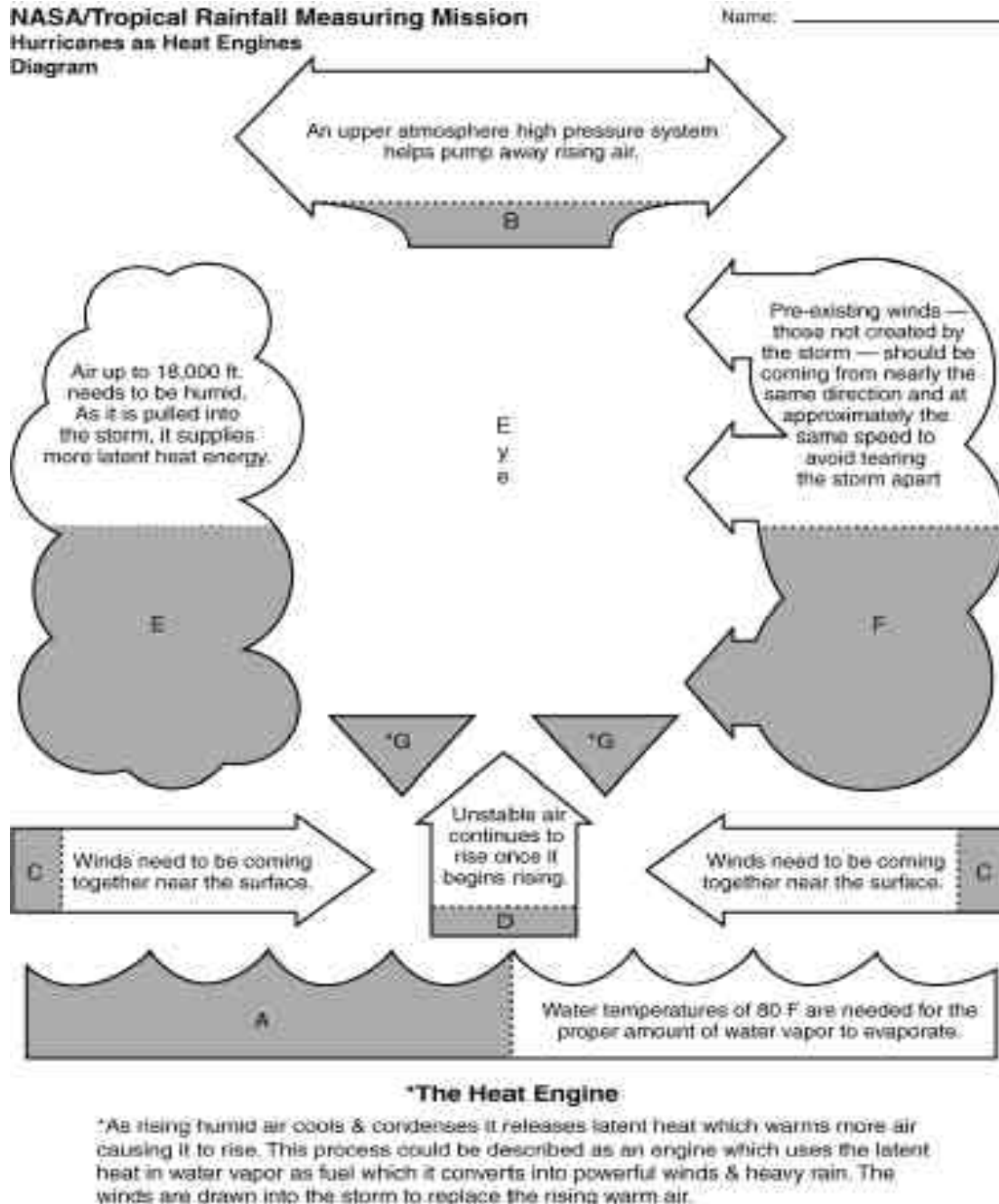
National Hurricane Center

<http://www.nhc.noaa.gov/>

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Diagram



National Science Education Standards

**The NASA/TRMM Activities support the following standards:
Contents Standards; Grades 5-8**

A. Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

B. Physical Science

- Properties and changes of properties in matter
- Transfer of energy

C. Life Science

D. Earth and Space Science

- Structure of the Earth

E. Science and Technology.

- Abilities of technological design
- Understandings about science and technology

F. Science in Personal and Social Perspectives

- Natural Hazards
- Science and technology in society

G. History and Nature of Science

- Science as a human endeavor
- Nature of science

Contents Standards; Grades 9-12

A. Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

B. Physical Science

- Structure and properties of matter
- Interactions of energy and matter

C. Life Science

D. Earth and Space Science

- Structure of the Earth
- Geochemical cycles

E. Science and Technology.

- Abilities of technological design
- Understandings about science and technology

F. Science in Personal and Social Perspectives

- Natural and human-induced hazards
- Science and technology in local, national and global challenges

G. History and Nature of Science

- Science as a human endeavor
- Nature of scientific knowledge